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Assessing risk factors for foodborne illness in restaurants in Seoul

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ABSTRACT

Restaurants are the most common locations for foodborne infectious disease outbreaks in Korea, accounting for almost half of the annual outbreaks nationwide. Although significant efforts have been made to reduce the incidence of foodborne illnesses, factors contributing to these outbreaks have not been adequately elucidated. The purpose of this study was to assess the risk factors for foodborne illnesses in restaurants in Seoul using the recommendations of the U.S. Food and Drug Administration. We used data from a survey conducted by the Seoul Metropolitan Government as part of a 2024 foodborne infectious disease control project. In the survey, of all registered restaurants in Seoul, 886 were selected and invited to participate using a systematic sampling method, and 400 voluntarily participated. The results showed that 10.3 % of restaurants had employee health policies for managing ill food workers, 8.3 % had a food hygiene certificate granted by the government, and 37.5 % provided paid sick leave. Additionally, the provision rate of guidance for handwashing and glove use was found to be low. Therefore, restaurants in Seoul were considered at an increased risk of foodborne infectious diseases. The study findings highlight the gaps in foodborne infectious disease control systems in restaurants in Seoul. Science-based customized approaches are required for controlling foodborne illnesses.

1. Introduction

Foodborne illness is a medical problem characterized by gastrointestinal symptoms, such as diarrhea and vomiting, caused by eating contaminated food. It can be transmitted as causative agents include microorganisms of bacteria, viruses, or parasites. Foodborne illness is a global concern, being more prevalent in low- and middle-income countries and especially affecting children under 5 years of age [1]. Because foodborne illness outbreaks continuously occur in community settings and their impact is considered significant in public health, some countries have surveillance systems for these outbreaks to minimize socioeconomic losses and disease burden [2–5].

The Republic of Korea is a member of the Organisation for Economic Co-operation and Development [6], and is classified as a high-income country by the World Bank [7]. With its rapid economic growth, the nation's overall health outcomes have dramatically improved [8]. However, regarding communicable disease management, the country showed an inadequate response to the outbreak of 2015 Middle East respiratory syndrome coronavirus, and the prevalence of tuberculosis remains relatively high [9]. The incidence of waterborne and foodborne infectious disease (WFID) outbreaks has also increased [10]. Kim and Kim reported that foodborne illnesses occurred 2.4 times more in Korea than in the United States (US) between 2011 and 2017 [11]. The incidence of foodborne outbreaks from 2015 to 2020 was 14.2 times higher in Korea than in the United Kingdom [10,12]. In 2023, foodborne outbreaks were reported 1.42 times more frequently in Korea than in Japan [10,13].

In Korea, 28 notifiable diseases are classified as WFIDs, and are monitored by the Korea Disease Control and Prevention Agency (KDCA). According to a recent KDCA annual report, 603 WFID outbreaks affecting 12,195 citizens occurred in Korea in 2023, a 34.2 % increase compared with the average incidence during the previous four years (2019–2022). Restaurants were the most common places for outbreaks, accounting for 46.1 % of cases, followed by cafeterias in schools and private educational institutes. Among the outbreaks in which microbial sources were identified, norovirus was the leading cause, accounting for 46.4 % of the outbreaks, followed by *Salmonella* (13.3 %) and *Escherichia coli* (8.0 %) [10].

In the US, retail food establishments including restaurants are considered the most common locations for foodborne outbreaks [2,14]. A recent report by the U.S. Centers for Disease Control and Prevention (CDC) revealed that the most common contributing factor to outbreaks in retail food establishments was food contamination by a food worker suspected of having an infectious disease [15]. To minimize infectious

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disease transmission by ill food workers, the U.S. Food and Drug Administration (FDA) has recommended effective hygiene practices and preventive measures for food establishments [16]. Among these, employee health policies for exclusion and restriction of ill food workers have been proved as being effective in improving food safety and reducing the risk of foodborne outbreaks [17,18]. A majority of restaurants in the US have said that they adopted a policy for ill food employee management [15,18,19].

Unlike the evidence-based approaches in the US, strategies for controlling foodborne illnesses in Korea have been implemented without a comprehensive understanding of the specific risk factors and characteristics of the various environments where WFIDs occur. The Korean government's WFID control guidelines focus on general practices, such as handwashing, proper cooking, annual health screenings, and food worker vaccinations, but it fail to identify specific risk factors for outbreaks [10]. Moreover, the Hygiene Grade Certificate program, introduced by the Ministry of Food and Drug Safety in 2017, lacks evidence-based foundation, and its effectiveness in controlling foodborne illnesses remains unclear [20,21].

Some studies have investigated risk factors in restaurant settings in Korea [22–24]. However, behavioral and environmental factors that increase the risk of WFIDs are not well understood. Addressing these gaps by adopting recommendations from the CDC and FDA can potentially decrease the incidence of WFIDs in Korea.

The purpose of this exploratory study was to assess the adoption rate of employee health policies and preventive measures in restaurants in Seoul. The study results highlight how key WFID control components are exercised in Seoul. The findings provide insights for developing effective strategies for managing WFIDs in Korea.

2. Materials and methods

Data used in this study were collected by the Seoul Metropolitan Government through a survey on assessing WFID control measures implemented in restaurants in Seoul as part of a foodborne infectious disease control project. The Food Sanitation Act defines two types of restaurants in Korea [25]. A casual restaurant refers to a restaurant in which tea, ice cream, and fast food are mainly served but alcoholic beverages are prohibited. A general restaurant refers to a restaurant in which meal can accompany alcoholic beverages. Data from both restaurant types were used in this study.

2.1. Sample

The sampling unit for this study was a restaurant, and the study population was all casual and general restaurants in Seoul. Participating restaurants were selected through a systematic sampling method using a comprehensive list of all casual and general restaurants in Seoul as of April 2024. The Ministry of the Interior and Safety maintains this list for restaurant registration and management purposes [26]. The list included 31,537 casual and 123,645 general restaurants. All restaurants were arranged in Korean alphabetical order based on their addresses for sampling purposes. Every 378th restaurant from a random starting point was selected and invited to participate in the study. To account for potential issues, such as registration errors, restaurant closures, refusal to participate, or visit during closing hours, nine substitute restaurants were designated for each selected restaurant. A sample size of 400 restaurants was calculated to provide 95 % confidence that the adoption rate of employee health policies and preventive measures was within 5 % of their actual prevalence.

2.2. Data collection

Data were collected from May to June 2024 at the participating restaurants using a paper-based data collection form. The form was designed to capture restaurant information, including restaurant type, existence of employee health policies, and adoption status of control measures for foodborne illness risk factors. Data collectors conducted unannounced visits to each restaurant based on convenience (to optimize travel time and cost). Upon arrival, an introductory letter explaining the purpose of the visit was presented to the restaurant staff. If an interview was denied, data collection was not performed, and a substitute restaurant replaced a visited but non-participating restaurant. The restaurant owner or person in charge was preferred for the interview, but any restaurant staff member was allowed to be interviewed.

After obtaining permission from the restaurant staff on duty, the data collectors conducted on-site interviews with the staff. A total of 41 questions were asked, of which 22 were related to this study; hence, the data gathered from these study-relevant questions were used. Eight questions were asked about the characteristics of the participating restaurants, and four questions were used to collect data regarding employee health policies. Hand hygiene, glove use, and toilet facilities were topics directly related to infectious disease transmission. Ten questions were asked on these topics. All data were recorded as reported by the restaurant staff without interpretation or interference from the data collectors.

2.3. Data analysis

Descriptive statistics were used to summarize restaurant characteristics and risk factors. All outputs were generated using Microsoft Excel 2013. All variables were presented as numbers and percentages.

Associations between restaurant characteristics and the adoption of employee health policies were analyzed using bivariate and multivariable logistic regression. Among variables related to restaurant characteristics, variables for the serving of ready-to-eat (RTE) foods and restaurant menus were excluded from the analysis. The variable for the serving of RTE foods was deemed inappropriate for inclusion because the information might not reflect actual data probably due to low awareness of the usual definition of RTE food, which is different from the Korean definition of RTE food. In Korea, RTE foods are considered home meal replacements and include items such as kimbap, sandwiches, and salads. These foods are manufactured, processed, packaged, consumed without cooking, and purchased in supermarkets or convenience stores [27,28]. The menu-related variable was excluded because one stratum had no data for the adoption of employee policies, precluding analysis. To facilitate analysis, categorical variables were converted to binary variables.

All variables that were statistically significant at $p < 0.05$ in the bivariate analysis were considered for inclusion in the multivariable model. A stepwise logistic regression approach was employed to identify the variables included in the final multivariable model. Potential interactions between the variables were assessed, but none of variables were eligible for interaction terms; thus, interaction terms were not included in the final model. The final model presented the odds ratios (ORs) with corresponding 95 % confidence intervals and significance levels as measures of association size. All regression analyses were conducted using STATA/IC version 11.0 (StataCorp, College Station, Texas).

3. Results

3.1. Restaurant characteristics

Of the 886 eligible restaurants, 400 (45.1 %) agreed to participate (Fig. 1). Among these, 73 (18.3 %) were registered as casual restaurants, whereas 327 (81.8 %) were classified as general restaurants. Approximately 60 % of restaurants operated independently, and the rest were franchise businesses. More than 80 % of restaurants served 100 meals or fewer per day, and employed five or fewer staff members; 36.0 % of restaurants employed only one cook. The most common menu type was Korean (35.8 %), and 49 (12.3 %) restaurants served RTE foods. Most

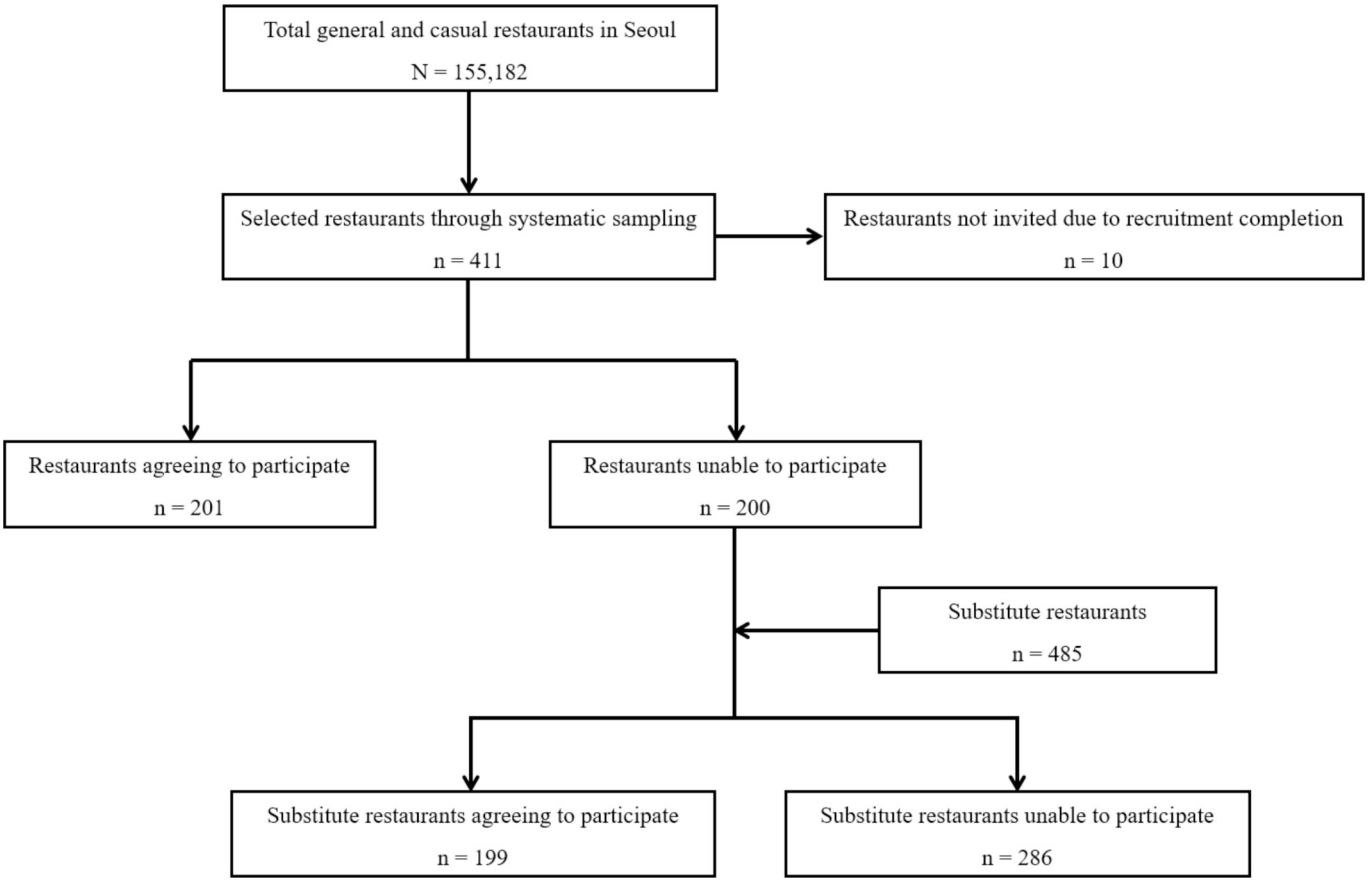

Fig. 1. Flow chart of study population sampling.

restaurants did not receive Hygiene Grade Certificates, with only 27 (6.8 %) graded as "excellent". A total of 150 (37.5 %) restaurants offered paid sick leave, whereas 206 (51.5 %) offered unpaid sick leave and 44 (11.0 %) did not provide sick leave (Table 1).

3.2. Employee health policies

A total of 41 (10.3 %) restaurants had written policies for managing ill employees. Thirty-seven (9.3 %) had policies requiring food workers to report disease symptoms or diagnoses of diseases to management and requiring management to manage ill employees. Guidance on exclusion and restriction of ill employees was included in the policies of 39 (9.8 %) restaurants, and 30 (7.5 %) identified specific exclusion and restriction periods for various WFIDs. Accordingly, only 29 (7.3 %) restaurants had all four components of employee health policies (Table 2).

3.3. Hand hygiene, use of glove, and toilet facility characteristics

Most restaurants provided hand cleaning soap for handwashing, whereas 263 (65.8 %) lacked dedicated handwashing sinks conveniently located for food workers. Approximately half of restaurants provided disposable towels or hand dryers at handwashing sinks, whereas 59 (14.8 %) did not provide any hand-drying items. Sixty-six (16.5 %) restaurants provided guidelines on handwashing. Although disposable gloves were commonly used in most restaurants, 333 (83.3 %) restaurants lacked guidance on their proper use. Most toilet facilities had at least one handwashing sink; however, touchless faucets were only installed in 39 (9.8 %) restaurants. Disposable towels or hand dryers were available in the toilet facilities of 235 (58.8 %) restaurants, while touchless doors— known to prevent hand recontamination —were installed in the toilet facilities of only 34 (8.5 %) restaurants (Table 3).

3.4. Restaurant characteristics and the adoption of employee health policies

Multiple logistic regression analysis identified four restaurant characteristics significantly associated with the adoption of employee health policies ($p < 0.05$) (Table 4). The adoption rate of these policies was greater in franchise businesses (adjusted OR = 3.69, $p = 0.002$), restaurants with Hygiene Grade Certificate (adjusted OR = 3.56, $p = 0.008$), those serving 101 meals or more per day (adjusted OR = 2.94, $p = 0.011$), and those with 6 employees or more (adjusted OR = 3.42, $p = 0.004$). Neither the type of restaurant registration nor the provision of sick leave type was significantly associated with the adoption of employee policies after adjusting for potential confounding factors in the multiple regression model.

4. Discussion

Most restaurants in Seoul had no written employee health policies, exposing them to a higher risk of WFIDs. Only 29 (7.3 %) restaurants had proper policies for managing ill food workers to ensure food safety, including guidelines for ill employee exclusion and restriction. Restaurants in Seoul were generally small in scale: 67.0 % had two or fewer cooks (Fig. 2), and 53.5 % prepared 50 meals or fewer per day. These findings were similar to the observation that 89.9 % of restaurants in Korea in 2020 were managed by four or fewer employees [29]. The availability of paid sick leave (37.5 %) was insufficient to support the exclusion of ill employees. These structural characteristics are the root causes of foodborne illness outbreaks in restaurants [30] and pose challenges to the effective control of WFIDs. These findings underscore the need to develop and implement tailored disease control strategies to supplement conventional measures like handwashing and adequate

Table 1
Characteristics of the participating restaurants.

Parameter	n	%
Restaurant registration type ($N = 400$)		
General	327	81.8
Casual	73	18.3
Restaurant operation type (N = 400)		
Independent	235	58.8
Franchise	165	41.3
Ready-to-eat foods[a] served ($N = 400$)		
No	351	87.8
Yes	49	12.3
Hygiene Grade Certificate[b] issued (N = 400)		
None	367	91.8
Good	3	0.8
Very good	3	0.8
Excellent	27	6.8
Number of meals served daily[c] (N = 400)		
≤50	214	53.5
51–100	113	28.3
101–150	35	8.8
≥151	38	9.5
Number of employees (N = 400)		
≤5	336	84.0
6–10	43	10.8
≥11	21	5.3
Type of sick leave (N = 400)		
Unavailable	44	11.0
Unpaid	206	51.5
Paid	150	37.5
Menu (N = 400)		
Korean	143	35.8
International	70	17.5
Alcoholic beverages	18	4.5
Non-alcoholic beverages	76	19.0
Other[d]	93	23.3

[a] Ready-to-eat food: food that is edible without additional preparation to achieve food safety.
[b] A system that evaluates the hygiene levels of restaurants and issues a certificate to businesses that receive excellent results [Excellent (★★★), Very Good (★★), Good (★)]. The evaluation is not legally mandatory and is conducted based on voluntary applications from restaurants.
[c] Number of meals on weekdays.
[d] Restaurants whose primary business is fast food, packaged food, food delivery, or bakeries.

Table 2
Interview data on employee health policies.

Question	Yes, no. (%)	No, no. (%)
Does this restaurant have written policies?	41 (10.3)	359 (89.8)
1. Does your policy include the responsibilities of food workers and managers, when a food worker has symptoms of a WFID[a] or is diagnosed with a WFID?[b]	37 (90.2)	4 (9.8)
2. Does your policy include guidance on exclusion and restriction of ill food workers?[b]	39 (95.1)	2 (4.9)
3. Does your policy include information on exclusion and restriction periods for different WFIDs?[b]	30 (73.2)	11 (26.8)

[a] WFID: waterborne and foodborne infectious disease.
[b] These questions were asked in restaurants with employee health policies.

cooking practices.

A risk assessment model study indicated that preventive measures for food safety are less effective when ill food workers are present in restaurants, making their exclusion critical [31]. The exclusion and restriction of ill employees are only feasible when applicable laws and regulations support food safety practices. For instance, the FDA Food Code in the US and Regulation (EC) No 852/2004 in the European Union provide a legal framework for managing ill workers [32,33]. In Korea, the Food Sanitation Act prohibits individuals infected with diseases designated as WFIDs of cholera, typhoid fever, paratyphoid fever, shigellosis, enterohemorrhagic *Escherichia coli* infection, and hepatitis A from working in food establishments [25]. However, these exclusion and restriction requirements do not apply to other WFIDs, such as norovirus infections and salmonellosis, or to symptoms such as diarrhea and vomiting. Consequently, no standard guidelines for managing ill restaurant employees are available in Korea.

Table 3
Interview data on the risk factors for waterborne and foodborne infectious diseases.

Question	Yes, no. (%)	No, no. (%)
Hand hygiene		
1. Are there handwashing sinks conveniently located for food workers but installed separately from food preparation sinks and service sinks?	137 (34.3)	263 (65.8)
2. Is hand cleanser[a] (hand cleaning liquid or bar soap) provided?	362 (90.5)	38 (9.5)
3. Are disposable towels or hand drying devices provided?	224 (56.0)	176 (44.0)
4. Are handwashing guidance or educational materials provided?	66 (16.5)	334 (83.5)
Use of glove		
1. Are single-use (disposable) gloves used?	394 (98.5)	6 (1.5)
2. Is guidance on glove use provided?	67 (16.8)	333 (83.3)
Toilet characteristics		
1. Do toilet rooms have touchless doors?	34 (8.5)	366 (91.5)
2. Do toilet rooms have at least one handwashing sink?	388 (97.0)	12 (3.0)
3. Are touchless faucets installed for handwashing sinks?	39 (9.8)	361 (90.3)
4. Are disposable towels or hand drying devices provided?	235 (58.8)	165 (41.3)

[a] Alcohol-based hand sanitizers were not included.

Proper handwashing and avoiding bare-hand contact with food are essential to preventing foodborne pathogen transmission in restaurants [16]. A previous study found that the absence of policies for handwashing or no bare-hand contact with RTE foods was associated with an increased risk of potential contamination actions by food handlers. Bare-hand or dirty glove contact with RTE foods was the most frequently observed contamination action [34]. Despite decades of efforts through various campaigns, the number of restaurants in Seoul with guidelines for handwashing and the use of gloves remains low.

Structural improvements, such as the proper placement of handwashing sinks and the installation of touchless equipment, could enhance hand hygiene practices. Given that food safety education is ineffective in improving structural hygiene compliance [35,36], government interventions in the form of policies that provide incentives to increase the marginal private benefits and reduce the marginal private costs for restaurants should be sought [37]. The low level of Hygiene Grade Certificate acquisition among Seoul restaurants should also be evaluated in terms of the adequacy of current government incentives.

According to the FDA Food Code, RTE food means food that is edible without additional preparation to achieve food safety [33]. RTE food is offered in various forms, such as frozen meals, boiled meals, and canned food, with a wide range of options, including main dishes, side dishes, desserts, and appetizers. This is an essential and practical concept for foodborne illness control. However, the definition of RTE foods in Korea differs from that of the FDA. In Korea, virtually no foods served in restaurants are considered ready-to-eat. The absence of a proper definition of RTE foods in Korea may hinder the adoption of no bare-hand contact practices. The low percentage of restaurants serving RTE foods in Seoul may reflect low awareness of the proper definition of RTE foods from a food safety perspective.

This study has strengths and limitations. The main strength is that a

Table 4
Rate of adoption of employee health policies by restaurant characteristics and associations between adoption rate and restaurant characteristics.

Restaurant characteristic	Rate of adoption of employee health policies, % (95 % CI[a])	Crude OR[b] (95 % CI)	*p*-value	Adjusted[c] OR (95 % CI)	*p*-value
Restaurant registration type			0.002		
General	7.95 (5.02–10.88)	1.00 [reference]			
Casual	20.55 (11.28–29.82)	2.99 (1.49–6.00)			
Restaurant operation type			<0.001		0.002
Independent	3.83 (1.38–6.28)	1.00 [reference]		1.00 [reference]	
Franchise	19.39 (13.36–25.43)	6.04 (2.80–13.05)		3.69 (1.61–8.46)	
Hygiene Grade Certificate issued			<0.001		0.008
No	7.63 (4.91–10.35)	1.00 [reference]		1.00 [reference]	
Yes	39.39 (22.72–56.07)	7.87 (3.54–17.47)		3.56 (1.39–9.11)	
Number of meals served daily			<0.001		0.011
≤100	5.81 (3.27–8.35)	1.00 [reference]		1.00 [reference]	
≥101	30.14 (19.61–40.66)	6.99 (3.54–13.83)		2.94 (1.28–6.75)	
Number of employees			<0.001		0.004
≤5	5.65 (3.19–8.12)	1.00 [reference]		1.00 [reference]	
≥6	34.38 (22.74–46.01)	8.74 (4.37–17.48)		3.42 (1.48–7.90)	
Sick leave type			0.011		
Unavailable/unpaid	7.20 (4.00–10.40)	1.00 [reference]			
Paid	15.33 (9.57–21.10)	2.33 (1.21–4.49)			

[a] CI = confidence interval.
[b] OR = odds ratio.
[c] Adjusted for restaurant operation type, Hygiene Grade Certificate issued, number of meals served daily, and number of employees.

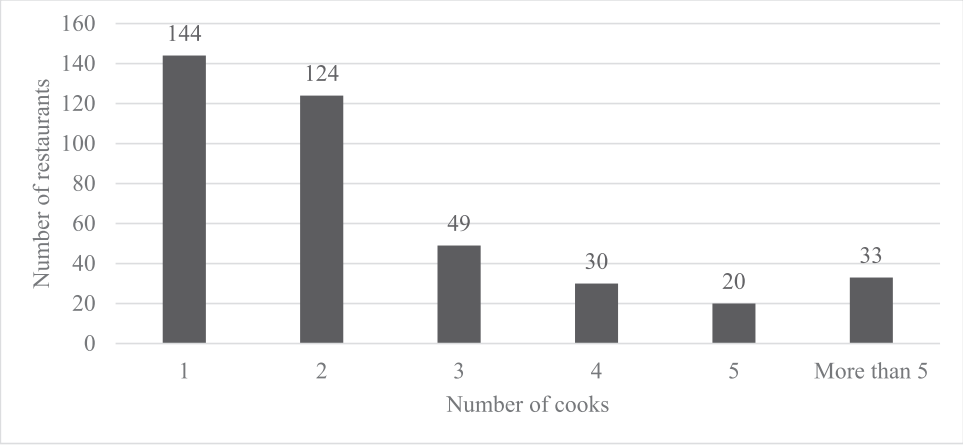

Fig. 2. Frequency distribution of number of cooks in restaurants in Seoul.

representative sample was obtained using a systematic sampling method based on a random-like ordering of restaurant addresses; thereby enhancing the generalizability of the findings. To our knowledge, this is the first study to describe the characteristics of Seoul restaurants in relation to WFID control practices using a representative sample. Another strength is the use of the FDA recommendations as assessment tools, enabling the identification of gaps in Korea's current food safety management system. The low participation rate (45.1 %) was a limitation of this study. The low response rate might have resulted in selection bias toward over-representing restaurants with better safety practices. The four restaurant characteristic variables for higher adoption rate of employee health policies were statistically associated with each other. However, we could not conclude the effect of these associations on the analysis because there were still possibilities of residual confounding and inaccurate designation of variables for restaurant characteristics. This is another limitation of the study. Because the study did not assess causal relationships between risk factors and the occurrence of WFIDs, the study findings cannot be directly interpreted as causative or contributing factors to the development of WFIDs in Seoul. Further research is needed to address these limitations.

5. Conclusions

Our findings highlight the gaps in foodborne infectious disease control systems in Seoul. To reduce the risk of food contamination by ill food workers in restaurants, it is essential to develop and implement tailored measures that support the exclusion and restriction of ill food workers and improve hygiene practices. These measures should be grounded in scientific evidence and proportionate to the associated public health risks. The results of this study provide valuable insights for formulating and implementing such evidence-based approaches.

Ethics approval

Not applicable.

CRediT authorship contribution statement

Joowon Lee: Writing – review & editing, Writing – original draft, Visualization, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Sooyoung Huh:** Writing – review & editing, Project administration, Methodology, Investigation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Data availability

The authors do not have permission to share data.

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